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(54) **CONDITION ANALYZER**

ZUSTANDSANALYSATOR

APPAREIL SERVANT A CONTROLER L'ETAT D'UNE MACHINE

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Description

Technical field

[0001] The present invention relates to a method for evaluating the condition of a machine having a measuring point, and a system for performing the method. The invention also relates to an analysis apparatus for evaluating the condition of a machine having a measuring point; and to a non-volatile memory having stored therein a computer program for controlling a condition analysis apparatus.

State of the art

[0002] Machines with moving parts are subject to wear with the passage of time. which often causes the condition of the machine to deteriorate. Examples of such machines with movable parts are motors, pumps, generators, compressors, lathes and CNC-machines. It is known to, more or less regularly, investigate the operating condition of such machines. The operating condition can be determined by measuring the amplitude of vibrations in a bearing and by measuring temperature changes on the casing of the machine, which temperatures are dependent on the operating condition of the bearing. Such condition checks of machines with rotating or other moving parts are of great significance for safety and also for the length of the life of such machines. It is known to perform such measurements on machines completely manually. This ordinarily is done by an operator with the help of a measuring instrument performing measurements at a number of measuring points on a machine. The measuring data obtained by means of the measuring instrument for each measuring point is noted down on a pre-printed form. For a machine it can be necessary to have a number of measuring points in order to later be able to determine the overall operating condition of the machine. For example, three measuring points are often used for the measurement of vibrations of a motor. In such a way that the vibrations are measured in three mutually perpendicular directions. I.e. in the X-direction. In the Y-direction and in the Z-direction. The operator must note down each measured value on the form. It is furthermore necessary for the operator to evaluate the measured values so that he can make a judgement on whether the measured amplitude measurement values indicate a change for a measuring position so that the machine can be serviced if the measured values indicate wear. This places a large demand on the professional knowledge of the service personnel of which vibration and temperature measurement values are acceptable and which measurement values are not acceptable.

[0003] In order to identify damage to bearings it is known to use a shock impulse measuring apparatus by means of which damage to bearings can be determined in machines with rotating machine parts. In order-to perform such measurements at a measuring point, the diameter of the shaft and the rotational speed of the shaft are set on a measuring scale. These values, which are set by hand, function as a reference level. If the measured values measured by means of the measuring instrument are greater than the reference level, this can be indicated by means of a warning lamp or by means of a sound signal.

[0004] It is known from EP-0 194 333 to provide each measuring point with identity data which is automatically readable by means of a separate reading probe. EP-0 194 333 also describes that the characteristic data values for the measuring point are readable at the measuring point so that the above described reference value can be generated automatically. The reference value is consequently calculated in a standardized and unambiguous way from the characteristic data values. Consequently, according to this known technique, the one and the same reference value is valid for all bearings with a certain shaft diameter and a certain rotational speed.

[0005] EP-0 211 212 describes a measuring instrument for detecting and evaluating data representative of the condition of a machine. The described measuring instrument has a measuring probe which is combined with a sensor probe for reading a measuring point code, whereby the measuring probe and the code sensing probe are provided in a common mobile casing.

Disclosure of the invention

[0006] The problem to be solved by the present invention is to provide a method which permits an increased accuracy in detecting changes of the condition of a machine.

[0007] This problem is solved according to the invention by a method for evaluating the condition of a machine having a measuring point, wherein a condition value is obtained by performing a measurement at the measuring point, said condition value being dependent on the actual condition of the machine; and

storing the condition value in a writable information carrier placed on or in the vicinity of, the measuring point so that the condition value subsequently can be used as a reference condition value, whereby possible later condition changes can be determined by comparison with said reference condition value.

[0008] According to a preferred embodiment, the reference condition value is produced depending on a measured value, such as a vibration value measured in connection with the final inspection of a newly manufactured machine, and on relevant interpreting information, such as shaft diameters and rotational speeds for a rotatable shaft of the machine.

[0009] With the object of providing a determination of whether some measurable condition change is present, a method according to an embodiment of the invention comprises the steps of:

producing a second actual condition value at a time point later than the time of production of said reference condition value, said second actual condition value being dependent on the actual condition at the measuring point, and
acquiring said reference condition value, from the information carrier which is placed on or in the vicinity of, the measuring point.

[0010] The method may further comprise the step of producing a relation value dependent on the second actual condition value and the reference condition value.

[0011] According to a preferred embodiment the production of the second actual condition value comprises the steps of:

producing a measured value by performing a measurement at the measuring point;
acquiring interpretation information from the information carrier; and
generating the second actual condition value dependent on the measured value and the interpretation information. According to another embodiment the second actual condition value is produced directly by performing a measurement at the measuring point.

[0012] A system for evaluating the condition of a machine comprises:

a movable analysis apparatus and a sensor unit for producing a condition value by performing a measurement at a measuring point on the machine, said condition value being dependent on movement and indicative of the actual condition of the machine; and
device comprising an information carrier placed on, or in the vicinity of, the measuring point of the machine. The analysis apparatus is arranged to store the condition value in the information carrier, which is writable, so that the condition value subsequently can be used as a reference condition value.

[0013] According to an embodiment of the system, the device comprises:

interpretation information, stored on the information carrier, which defines technical type values for the machine and/or the movable part in such a way that the actual condition value can be generated dependent on an actual measured value and the interpretation information. The device also comprises communication means for co-operating with the information carrier and for communicating with the analysis apparatus. The device may also comprise a communication means for co-operating with the analysis apparatus, which, dependent on an activating signal, reads interpretation information from the information carrier and delivers this information to the analysis apparatus; wherein the communication means, dependent on the activation signal, reads the reference condition value from the information carrier and delivers this to the analysis apparatus thereby enabling the generation of a relation value indicating a changed condition.

[0014] The communication means can comprise a transceiver for communicating with the analysis apparatus by means of radio communication or optical transmitters and optical receivers. The communication means can comprise contact means for ohmic contact between the information carrier and the analysis apparatus .

[0015] The invention also relates to an analysis apparatus for evaluating the condition of a machine having a measuring point, which apparatus comprises:

a sensor means for producing a measured value dependent on a movement of the machine;
a communication means for receiving interpretation information;
an information processing means for producing a condition value. The information processing means co-operates with the communication means and the sensor means so that the information processing means produces a condition value, dependent on the measured value and the interpretation information, indicating the actual condition of the machine.

The communication means comprises an interface means which is arranged to transmit the condition value to a writable information carrier placed on, or in the vicinity of, the measuring point so that it can be used as a locally stored individual condition reference value specific to the measuring point, whereby possible later condition changes can be determined by comparison with said reference condition value.

[0016] The invention also relates to a non-volatile memory having stored therein a computer program for controlling a condition analysis apparatus having a micro-processor, a read/write memory and said non-volatile memory, the computer program comprising:

a program function which, when run on the microprocessor, causes the analysis apparatus to produce a condition value, dependent on the actual condition of a machine, by perforning a measurement at a measuring point of the machine; and
a program function which, when run on the microprocessor, causes the analysis system to store the condition value as a reference value in a writable information carrier placed on, by, or in the vicinity of, the measuring point.

Description of the drawings

[0017] In order to make the present invention easy to understand and produce, it will be described with reference to the appended drawings:

Fig. 1 shows a schematic block diagram of an embodiment of a condition analyzing system according to the invention.

Fig. 2A shows an embodiment of a sensor unit which comprises an interface for communication with an information carrier at a measuring point.

Fig. 2B shows an embodiment of a device at a measuring point comprising an information carrier and an interface for communication with the interface according to Fig. 2A.

Preferred embodiments

[0018] Fig. 1 shows a schematic block diagram of an embodiment of a condition analyzing system 10 according to the invention. The condition analyzing system comprises a sensor unit 20 for producing a measured value dependent on movement and, more precisely, dependent on vibrations.

[0019] The sensor unit 20 is connected to an analysis apparatus 30 via a conductor 32. The analysis apparatus 30 comprises a non-volatile memory 40, a microprocessor 50 and a read/write memory 60. A computer program is stored in the read memory 40, and by means of this computer program the function of the analysis apparatus 30 is controlled. When it is written below that the microprocessor 50 performs a certain function, it shall be understood that the microprocessor runs a certain part of the program which is stored in the memory 40.

[0020] The microprocessor 50 is connected to a display unit 62. By means of the display unit 62 a user of the condition analyzing system is informed of the condition of the current measuring point in clear text. The production of a condition value is described more closely below. The display arrangement can comprise, on the one hand a screen, on the other hand a printer unit, so that the user can have the condition value from the measuring point printed out if so desired.

[0021] According to a preferred embodiment the analysis apparatus 30 comprises a screen 62 on which relevant information is shown during the measuring, and a diskette station 64 in which a diskette is introduceable. In this way the user with the help of the analysis apparatus 30 collects the condition values for a plurality of measuring points and save all the information on a diskette removably introduced into the diskette unit 64. The microprocessor 50 is further connected to an information port 66, by means of which the apparatus 30 can be connected to a separate information processing unit.

[0022] The analysis apparatus 30 is equipped with an interface 70 for the exchange of data, with a device 80. When the system is operative, the device 80 is firmly mounted on or at a measuring point 90 on a machine 100 with a movable part 110. A measuring point can comprise a connection coupling firmly attached to the casing of the machine to which the sensor unit is removably attachable. The connection coupling can, for example, be formed of a bayonet coupling. A measuring point can comprise a threaded recess in the casing in which the sensor unit is screwable. In the last case the sensor unit 20 comprises corresponding threads so that it can be introduced into the recess like a screw.

[0023] Alternatively, the measuring point is marked on the casing of the machine only with a painted mark.

[0024] The machine 100 exemplified in Fig. 1 has a rotating shaft 110 with a certain shaft diameter d_1. Shaft 110 in the machine 100 rotates at a certain speed of rotation V_1 when the machine is in use.

[0025] The apparatus 80 comprises an information carrier 120 which is equipped with information on the identity of the measuring point and interpreting information. The information carrier is furthermore equipped with at least one condition value K_{ref} which can be used as reference for determining a possible change in the condition.

[0026] The identity information can be formed of, for example, the identity number of the measuring point or of a data string which identifies both the machine 100 and the measuring point 90. The machine 100, which is only partly shown in Fig. 1, can comprise a number of measuring points and a number of moving parts so that the condition of different parts of the machine can be determined individually. The interpretation data stored in the measuring point device 80 can comprise a first computer word indicating the above mentioned shaft diameter d_1 and a second computer word indicating the speed of rotation V_1. The information carrier 120 is connected to an interface unit 130 for exchanging information with the interface unit 70 of the analysis apparatus 30. An operator transports the portable analysis apparatus 30 to the measuring point for which the condition value is to be determined and attaches the sensor unit 20 to the measuring point 90. According to one embodiment the sensor unit 20 is provided with a change-over switch (not shown) which closes in dependence of the sensor unit being brought into contact with the measuring point 90. When the change-over switch closes, an activating signal is produced which, via the bus 32 is delivered to the microprocessor 50 and thereby activates the microprocessor to perform an analysis routine. An actual condition value is determined by the analysis routine, and a reference value K_{ref} acquired from the information carrier 120. The reference value K_{ref} indicates the condition value for the individual machine for the same measuring point at an earlier point of time. The reference value K_{ref} is stored in the information carrier in the same way as described below.

[0027] When the machine is new from the factory or when a bearing for a rotatable shaft 110 is renovated or exchanged, a condition value K_{ref} for each measuring point 90 of the machine 100 is determined.

[0028] The condition reference value for the measuring point is determined according to a preferred embodiment by producing a measured value indicating the vibration or temperature of the machine at the measuring

point and, in a known way, with the help of interpretation information, such as shaft diameter and speed of rotation of the shaft, transforming the measured value into a condition value. Because this condition value K_{ref} is produced when the corresponding machine part is new or newly renovated, possible later condition changes can be advantageously determined by comparison with the reference K_{ref}.

[0029] When the apparatus 30 is used to produce the reference condition value K_{ref}, a keyboard is connected to the information port 66 and the microprocessor is instructed to perform a reference-producing routine. The reference-producing routine involves the microcomputer 30 acquiring a measuring value from the sensor unit 20 and the display unit 62 showing a request for the operator to input the interpretation information which applies for the measuring point.

[0030] The interpretation information can be inputted, for example, via the keyboard or by means of a diskette which is introduced into the diskette station 64.

[0031] The microcomputer calculates the actual condition value K_{ref} indicating the condition of the individual measuring point depending on the measured value and the inputted interpretation information.

[0032] Both the condition reference value K_{ref} and the inputted interpretation information determined in this way are delivered to the information carrier 120 via the interface 70.

[0033] Alternatively, the interpretation data as well as the reference value K_{ref} can be delivered to the diskette unit 64 or the display unit/screen 62 in order to be inputted to the information carrier 120 in another way.

[0034] According to a preferred embodiment of the invention the device 80 comprises a readable and writable memory 120 which can exchange information in both directions with the interface 130. According to one embodiment the device 80 comprises a photoelectric cell which provides the power supply to the memory 120 and the interface 130.

[0035] Because the device 80 in the above described way is applied with a condition reference value which is individual for the machine and for the measuring point, later condition measuring can give advantageously accurate indications about changes in the condition. This means that the analysis apparatus does not have to be provided with any information at all about the machine or its measuring point, and despite this it is still possible to achieve an accurate evaluation of whether any changes in the condition have occurred. This is of considerable advantage, for example, during the checking of the condition of machines fixed to the floor in a large manufacturing industry, where the number of machines and measuring points is very large. It further provides a very good security as the risk of mixing of the data in a data base is eliminated by the reference condition value being stored directly at the measuring point.

[0036] A method for determining a possible change in the condition is usually performed with a certain regularity by maintenance personnel. A first example of when such a process can be performed, according to the invention, is when a machine has just been installed after delivery. In this situation there is already a condition reference value in the information carrier which has been generated and stored there in connection with the final inspection at the manufacturer of the machine..

[0037] When the installator has just installed the machine, the process is performed for determining a possible change in the condition with the purpose of verifying that the installation is correct and that the condition of the machine has not deteriorated during the transport from the manufacturer.

[0038] The method comprises the steps of:

- producing a measured value which depends on a movement of the machine;
- acquiring interpretation information from an information carrier which is mounted by the measuring point;
- producing an actual condition value, indicating the actual condition of the measuring point on the machine, dependent on the measured value and the interpretation;
- acquiring a second condition value, indicating the condition of the measuring point at an earlier point of time, from the information carrier;
- producing a relation value dependent on the actual condition value and the second condition value, which relation value indicates a change in the condition.

[0039] This process can be performed by the microprocessor 50 running an analysis routine which is stored in the memory 40.

[0040] The analysis routine comprises the step of the microprocessor 50 requesting measured values from the sensor unit 20. According to one embodiment of the invention the sensor unit comprises an accelerometer 140 with a piezo-electric element. When the measuring point 90 vibrates, the sensor unit 20, or at least a part of it, also vibrates and the accelerometer 140 then produces an electrical signal of which the frequency and amplitude depend on the mechanical vibration frequency and the vibration amplitude of the measuring point 90, respectively. The electrical signal is delivered to the analog-digital converter 34 which with a certain sampling frequency f_s converts the analog signal to consecutive digital words in a known way. The microcomputer 50 stores a series of digital words which correspond to a time sequence of the electrical signal in the memory 60, and then performs an analysis of the signal sequence, whereby the frequency and amplitude of the signal is determined. Consequently, a measured value for the vibration amplitude A_v and the vibration frequency f_v is determined. The microcomputer then takes the interpretation information and the reference value K_{ref} from the device 80 by reading information from the in-

terface 70.

[0041] According to one embodiment, the interface 130 on the device 80 comprises an opto-transmitter which transfers data serially to the interface 70 in the form of trains of pulses of infrared light.

[0042] The device 80 can be activated depending on an information request which is received via the interface 130. Alternatively, the device 80 comprises a detector element which senses if the sensor unit 20 is applied to the measuring point 90 and then activates the device 80 to send information to the interface 130.

[0043] In this way the microcomputer receives information on the identity of the measuring point and interpretation information, such as the diameter value d_1 and the rotational speed value V_1.

[0044] With knowledge of the interpretation information d_1 resp. V_1, each measured vibration amplitude value A_v can be easily converted to an actual condition value K_a. A predetermined interpretation algorithm is stored in the memory 40 and starting from an amplitude value A_v and interpretation information, such as d_1 and V_1, the microcomputer produces a corresponding condition value K_a dependent thereon. Such an interpretation algorithm is based on an embodiment of a method for producing a condition value described in the Swedish Laid-Open Document 339 576.

[0045] According to one embodiment, the interpretation algorithm is based on the machine classification standard ISO 2954.

[0046] The actual condition value K_a produced and the reference condition value K_{ref} acquired from the information carrier 120 are delivered to the screen 62 so that the operator can judge if the two values correspond. If K_a is essentially similar to K_{ref}, the condition is essentially unchanged. If there is a discrepancy between the two values, then this indicates that the condition of the machine has changed.

[0047] Because the actual condition value K_a according to the invention can be compared with an earlier measured condition value K_{ref} for the same measuring point, an extremely accurate indication of changes is achieved. In this way, advantageously well-judged decisions can be made on when maintenance is required, which in turn leads to that the life length of the machine can be increased.

[0048] According to a preferred embodiment, the microcomputer produces a relation value in dependence of the actual condition value K_a and the reference condition value K_{ref}.

[0049] By dividing the value K_a with the reference K_{ref}, a relation value is achieved which gives a percentage change of the condition of the machine part or parts to which the measuring points relate. According to another embodiment the relation value is produced as the difference between the value K_a and the reference K_{ref}.

Claims

1. A method for evaluating the condition of a machine (100) having a measuring point (90), wherein a condition value is obtained by performing a measurement at the measuring point, said condition value being dependent on the actual condition of the machine;
   characterized by
   storing the condition value in a writable information carrier (120) placed on or in the vicinity of, the measuring point (90) so that the condition value subsequently can be used as a reference condition value, whereby possible later condition changes can be determined by comparison with said reference condition value.

2. The method according to Claim 1, **characterized by**
   producing a measured value;
   acquiring interpretation information (d_1, V_1);
   generating the condition value dependent on the measured value (A_v) and the acquired interpretation information (d_1, V_1).

3. The method according to Claim 1 or 2, **characterized in that** the measured value indicates a movement, such as a vibration, of the machine.

4. The method according to Claim 1, 2 or 3, **characterized in that** the measured value indicates a temperature of the machine at the measuring point.

5. The method according to claim 2, **characterized in that** the interpretation information (d_1, V_1) corresponds to the technical type values for the machine or a part of the machine.

6. The method according to any of the previous claims, **characterized in that**
   the measurement involves the step of attaching a sensor (20) to the measuring point.

7. The method according to claim 1, further comprising the steps of:
   producing a second actual condition value at a time point later than the time of production of said reference condition value, said second actual condition value being dependent on the actual condition at the measuring point,
   acquiring said reference condition value from the information carrier (120) which is placed on or in the vicinity of, the measuring point (90).

8. The method according to Claim 7, further comprising the step of:

producing a relation value dependent on the second actual condition value and the reference condition value.

9. Method according to Claim 7 or 8, **characterized in that** production of the second actual condition value comprises the steps of:

producing a measured value by performing a measurement at the measuring point;
acquiring interpretation information from the information carrier (120); and
generating the second actual condition value (K) dependent on the measured value (A_v) and the interpretation information (d_1, V_1).

10. The method according to Claim 7 or 8, **characterized in that** the second actual condition value is produced directly by performing a measurement at the measuring point.

11. The method according to any of the previous claims, **characterized by** communicating with the information carrier by radio or optical communication.

12. An analysis apparatus for evaluating the condition of a machine (100) having a measuring point (90), which apparatus comprises:

a sensor means (20) for producing a measured value (A_v) dependent on a movement of the machine;
a communication means (70;66;64) for receiving interpretation information;
an information processing means (50,40,60) for producing a condition value, **characterized in that**
the information processing means (50,40,60) co-operates with the communication means (70;66;64) and the sensor means (20) so that the information processing means produces a condition value ($K;K_{ref}$), dependent on the measured value and the interpretation information, indicating the actual condition of the machine,
the communication means comprises an interface means (70) which is arranged to transmit the condition value (K_{ref}) to a writable information carrier (120) placed on or in the vicinity of, the measuring point (90) so that it can be used as a locally stored individual condition reference value specific to the measuring point, whereby possible later condition changes can be determined by comparison with said reference condition value.

13. The analysis apparatus according to Claim 12, **characterized in that**
the interface means (70) is capable of both receiving and transmitting information.

14. The analysis apparatus apparatus according to Claim 12, **characterized in that**
the sensor means (20) is movably connected to the information processing means.

15. The analysis apparatus according to Claim 12, 13 or 14, **characterized in that**
the interface means (70) and the sensor means (20, 140) are integrated in a common casing.

16. The analysis apparatus according to any of Claims 12-15, **characterized in that** the analysis apparatus is arranged to generate the condition value in accordance with a predetermined algorithm.

17. The analysis apparatus according to any of Claims 12-16, **characterized in that** the analysis apparatus is a portable unit.

18. The analysis apparatus according to any of Claims 12-17, **characterized in that**
the interface means (70) is adapted to communicate with the information carrier by means of radio communication or by means of optical transmitters and optical receivers.

19. A system for evaluating the condition of a machine comprising:

a movable analysis apparatus (30) and a sensor unit (20) for producing a condition value by performing a measurement at a measuring point on the machine, said condition value being dependent on movement and indicative of the actual condition of the machine; and
a device (80) comprising an information carrier (120) placed on, at, or in the vicinity of the measuring point (90) of the machine;

characterized in that
the analysis apparatus (30) is arranged to store the condition value in the information carrier (120), which is writable, so that the condition value subsequently can be used as a reference condition value.

20. The system according to claim 19, wherein the_device (80) comprises:
Interpretation information, stored on the information carrier, which defines technical type values for the machine and/or the movable part in such a way that the actual condition value can be generated dependent on an actual measured value and the

Interpretation information.

21. The system according to Claim 20, wherein
the device (80) comprises communication means (130) for co-operating with the information carrier (120) and for communicating with the analysis apparatus (30).

22. The system according to Claim 21, **characterized in that**
the communication means (130) comprises a transceiver for communicating with the analysis apparatus (30) by means of radio communication or optical transmitters and optical receivers.

23. The system according to Claim 21, **characterized in that**
the communication means (130) comprises contact means for ohmic contact between the information carrier (130) and the analysis apparatus (30,70).

24. The system according to any of Claims 19-23, **characterized in that**
the condition value produced by said sensor is dependent on vibrations

25. The system according to any of Claims 19-23, **characterized in that**
the device (80) is firmly mounted on the machine (100) on, at, or in the vicinity of, the measuring point (90).

26. The system according to any of Claims 19-25, **characterized in that**
the measuring point comprises a connection coupling which is firmly attached to the casing of the machine (100); the sensor unit being removably attachable to the connection coupling.

27. The system according to claim 26, **characterized in that**
the connection coupling is a bayonet coupling.

28. The system according to any of Claims 19-26, **characterized in that**
the measuring point comprises a threaded recess in the casing of the machine (100) in which the sensor unit is screwable.

29. The system according to claim 28, **characterized in that**
the sensor unit (20) comprises corresponding threads so that it can be introduced into the recess like a screw.

30. The system according to any of claims 19-29, **characterized in that**
the analysis apparatus (30) comprises a non-volatile memory (40), a read/write memory (60), a microprocessor (50) and a display unit (62) for displaying the condition of a current measuring point.

31. The system according to claim 30, **characterized in that**
the microprocessor (50) is connected to an information port (66), by means of which the analysis apparatus (30) can be connected to a separate information processing unit.

32. The system according to claim 20, wherein the device (80) comprises a communication means (130) for co-operating with the analysis apparatus, which, dependent on an activating signal, reads interpretation information from the information carrier and delivers this information to the analysis apparatus; and wherein the communication means, dependent on the activation signal, reads the reference condition value from the information carrier and delivers this to the analysis apparatus thereby enabling the generation of a relation value indicating a changed condition.

33. A non-volatile memory (40) having stored therein a computer program for controlling a condition analysis apparatus (30) having a micro-processor (50), a read/write memory and said non-volatile memory (40),
the computer program comprising:
a program function which, when run on the microprocessor, causes the analysis apparatus to produce a condition value, dependent on the actual condition of a machine, by performing a measurement at a measuring point of the machine;
characterized by
a program function which, when run on the microprocessor, causes the analysis system to store the condition value as a reference value in a writable information carrier (120) placed on, by, or in the vicinity of, the measuring point (90).

34. The non-volatile memory according to claim 33, wherein the computer program further comprises:

a program function which, when run on the microprocessor, causes the analysis apparatus to produce a measured value which depends on a movement of the machine;
a program function which, when run on the microprocessor, causes the analysis apparatus to acquire interpretation information from the information carrier which is mounted on, by, or in the vicinity of, the measuring point;
a program function which, when run on the microprocessor, causes the analysis apparatus to

produce an actual condition value, indicating the actual condition of the measuring point on the machine, dependent on the measured value and the interpretation information;
a program function which, when run on the microprocessor, causes the analysis apparatus to acquire said reference condition value, indicating the condition of the measuring point at an earlier point of time, from the information carrier;
a program function which, when run on the microprocessor, causes the analysis apparatus to produce a relation value dependent on the actual condition value and the reference condition value, which relation value indicates a change in the condition of the machine.

Patentansprüche

1. Verfahren zur Bestimmung des Zustands einer Maschine (100), die einen Messpunkt (90) hat, wobei ein Zustandswert durch Durchführen einer Messung am Messpunkt erhalten wird, wobei der Zustandswert abhängig von dem gegenwärtigen Zustand der Maschine ist;
gekennzeichnet durch
Speicherung des Zustandswerts in einem beschreibbaren Informationsträger (120), der an oder in der Nähe des Messpunkts (90) angeordnet ist, so dass der Zustandswert nachfolgend als Referenzzustandswert verwendet werden kann, wodurch mögliche spätere Zustandsänderungen **durch** Vergleich mit dem Referenzzustandswert bestimmt werden können.

2. Verfahren nach Anspruch 1, **gekennzeichnet durch**

   Erzeugen eines Messwerts;

   Erlangen von Auswertungsinformation (d_1, V_1);

   Erzeugen des Zustandswerts abhängig von dem gemessenen Wert (A_v) und der ermittelnden Auswertungsinformation (d_1, V_1).

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der gemessene Wert eine Bewegung der Maschine, wie eine Vibration, anzeigt.

4. Verfahren nach Anspruch 1, 2 oder 3, **dadurch gekennzeichnet, dass** der gemessene Wert eine Temperatur der Maschine am Messpunkt anzeigt.

5. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** die Auswertungsinformation (d_1, V_1) den technischen Gattungswerten der Maschine oder eines Teils der Maschine entspricht.

6. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Messung den Schritt des Anbringens eines Sensors (20) an dem Messpunkt umfasst.

7. Verfahren nach Anspruch 1, weiter umfassend die Schritte:

   Erzeugen eines zweiten gegenwärtigen Zustandswerts zu einem späteren Zeitpunkt als dem Zeitpunkt des Erzeugens des Referenzzustandswerts, wobei der zweite gegenwärtige Zustandswert abhängig vom gegenwärtigen Zustand am Messpunkt ist;

   Erlangen des Referenzzustandswerts von dem Informationsträger (120), der auf dem Messpunkt (90) oder in dessen Nähe platziert ist.

8. Verfahren nach Anspruch 7, weiter umfassend den Schritt:
Erzeugen eines Bezugswerts abhängig von dem zweiten gegenwärtigen Zustandswert und dem Referenzzustandswert.

9. Verfahren nach Anspruch 7 oder 8, **gekennzeichnet dadurch**, dass das Erzeugen des zweiten gegenwärtigen Zustandswerts die Schritte umfasst:

   Erzeugen eines Messwerts **durch** Durchführen einer Messung am Messpunkt;

   Erlangen von Auswertungsinformation von dem Informationsträger (120); und

   Erzeugen des zweiten gegenwärtigen Zustandswerts (K) abhängig von dem gemessenen Wert (A_v) und der Auswertungsinformation (d_1, V_1).

10. Verfahren nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** der zweite gegenwärtige Zustandswert direkt durch Durchführen einer Messung am Messpunkt erzeugt wird.

11. Verfahren nach einem der vorhergehenden Ansprüche, **gekennzeichnet durch** Übermitteln zu dem Informationsträger **durch** Funkverbindung oder optische Verbindung.

12. Analysegerät zum Bestimmen des Zustands einer Maschine (100), die einen Messpunkt (90) hat, wobei das Gerät umfasst:

eine Sensoreinrichtung (20) zur Erzeugung eines Messwerts (A_v) abhängig von einer Bewegung der Maschine;

eine Verbindungseinrichtung (70, 66, 64) zum Empfang von Auswertungsinformation;

eine Informationsverarbeitungseinrichtung (50, 40, 60) zum Erzeugen eines Zustandswerts;

dadurch gekennzeichnet, dass

die Informationsverarbeitungseinrichtung (50, 40, 60) mit der Verbindungseinrichtung (70, 66, 64) und der Sensoreinrichtung (20) zusammenwirkt, so dass die Informationsverarbeitungseinrichtung einen Zustandswert (K; K_{ref}) in Abhängigkeit von dem Messwert und der Auswertungsinformation erzeugt, der den gegenwärtigen Zustand der Maschine anzeigt;

die Verbindungseinrichtung eine Schnittstelleneinrichtung (70) umfasst, die so angeordnet ist, dass sie den Zustandswert (K_{ref}) zu einem beschreibbaren Informationsträger (120) überträgt, der auf dem Messpunkt (90) oder in dessen Nähe platziert ist, so dass er als lokal gespeicherter individueller Bezugszustandswert spezifisch für den Messpunkt verwendet werden kann, wodurch mögliche spätere Zustandsänderungen durch Vergleich mit dem Bezugszustandswert ermittelt werden können.

13. Analysegerät nach Anspruch 12, **dadurch gekennzeichnet, dass** die Schnittstelleneinrichtung (70) sowohl zum Senden als auch zum Empfangen von Information fähig ist.

14. Analysegerät nach Anspruch 12, **dadurch gekennzeichnet, dass** die Sensoreinrichtung (20) bewegbar mit der Informationsverarbeitungseinrichtung verbunden ist.

15. Analysegerät nach Anspruch 12, 13 oder 14, **dadurch gekennzeichnet, dass** die Schnittstelleneinrichtung (70) und die Sensoreinrichtung (20, 140) in einem gemeinsamen Gehäuse integriert sind.

16. Analysegerät nach einem der Ansprüche 12 bis 15, **dadurch gekennzeichnet, dass** das Analysegerät angeordnet ist, dass es den Zustandswert in Übereinstimmung mit einem vorbestimmten Algorithmus erzeugt.

17. Analysegerät nach einem der Ansprüche 12 bis 16, **dadurch gekennzeichnet, dass** das Analysegerät eine tragbare Einheit ist.

18. Analysegerät nach einem der Ansprüche 12 bis 17, **dadurch gekennzeichnet, dass** die Schnittstelleneinrichtung (70) dazu angepasst ist, mit dem Informationsträger durch Funkverbindung oder durch optische Transmitter und optische Empfänger in Verbindung zu stehen.

19. System zum Ermitteln des Zustands einer Maschine, umfassend:

ein bewegbares Analysegerät (30) und eine Sensoreinheit (20) zum Erzeugen eines Zustandswerts durch Durchführen einer Messung an einem Messpunkt auf der Maschine, wobei der Zustandswert abhängig von Bewegung ist und den gegenwärtigen Zustand der Maschine angibt; und

eine Einrichtung (80), die einen Informationsträger (120) umfasst, der auf, an oder in der Nähe des Messpunkts (90) der Maschine platziert ist;

dadurch gekennzeichnet, dass das Analysgerät (30) den Zustandswert in dem Informationsträger (120) speichern kann, der beschreibbar ist, so dass der Zustandswert nachfolgend als ein Bezugszustandswert verwendet werden kann.

20. System nach Anspruch 19, wobei die Einrichtung (80) umfasst:
Auswertungsinformation, die auf dem Informationsträger gespeichert ist, die technische Gattungswerte für die Maschine und/oder des beweglichen Teils in solch einer Weise definiert, dass der gegenwärtige Zustandswert abhängig von einem gegenwärtig gemessenen Wert und der Auswertungsinformation erzeugt werden kann.

21. System nach Anspruch 20, wobei die Einrichtung (80) eine Verbindungseinrichtung (130) zum Zusammenwirken mit dem Informationsträger (120) und zur Verbindung mit dem Analysegerät (30) umfasst.

22. System nach Anspruch 21, **dadurch gekennzeichnet, dass**
die Verbindungseinrichtung (130) einen Transceiver zur Verbindung mit dem Analysegerät (30) durch Funkverbindung oder optische Transmitter und optische Receiver umfasst.

23. System nach Anspruch 21, **dadurch gekennzeichnet, dass** die Verbindungseinrichtung (130) Kontaktmittel zur leitenden Verbindung zwischen dem Informationsträger (130) und dem Analysegerät (30, 70) umfasst.

24. System nach einem der Ansprüche 19 bis 23, **dadurch gekennzeichnet, dass** der durch den Sensor erzeugte Zustandswert abhängig von Vibrationen ist.

25. System nach einem der Ansprüche 19 bis 23, **dadurch gekennzeichnet, dass** die Einrichtung (80) fest auf der Maschine (100) auf, an oder in der Nähe des Messpunkts (90) montiert ist.

26. System nach einem der Ansprüche 19 bis 25, **dadurch gekennzeichnet, dass** der Messpunkt eine Anschlusskupplung umfasst, die fest an dem Gehäuse der Maschine (100) angebracht ist; wobei die Sensoreinheit entfernbar an der Anschlusskupplung anbringbar ist.

27. System nach Anspruch 26, **dadurch gekennzeichnet, dass** die Anschlusskupplung eine Bajonettkupplung ist.

28. System nach einem der Ansprüche 19 bis 26, **dadurch gekennzeichnet, dass** der Messpunkt eine Aussparung mit Gewinde in dem Gehäuse der Maschine (100) umfasst, in das die Sensoreinheit einschraubbar ist.

29. System nach Anspruch 28, **dadurch gekennzeichnet, dass** die Sensoreinheit (20) entsprechende Gewinde umfasst, so dass sie in die Aussparung wie eine Schraube eingeführt werden kann.

30. System nach einem der Ansprüche 19 bis 29, **dadurch gekennzeichnet, dass**
das Analysegerät (30) einen nicht-flüchtigen Speicher (40), einen Read/Write-Speicher (60), einen Mikroprozessor (50) und eine Anzeigeeinheit (62) zum Anzeigen des Zustands eines gegenwärtigen Messpunkts umfasst.

31. System nach Anspruch 30, **dadurch gekennzeichnet, dass**
der Mikroprozessor (50) mit einem Informationsport (66) verbunden ist, durch den das Analysegerät (30) mit einer getrennten Informationsverarbeitungseinheit verbunden werden kann.

32. System nach Anspruch 20, wobei die Einrichtung (80) eine Verbindungseinrichtung (130) zum Zusammenwirken mit dem Analysegerät umfasst, die abhängig von einem Aktivierungssignal Auswertungsinformation von dem Informationsträger liest und diese Information an das Analysegerät liefert; und wobei die Verbindungseinrichtung abhängig von dem Aktivierungssignal den Bezugszustandswert von dem Informationsträger liest und diesen an das Analysegerät liefert, wodurch das Erzeugen eines Verhältniswerts ermöglicht wird, der einen geänderten Zustand angibt.

33. Nicht-flüchtiger Speicher (40), der in ihm ein Computerprogramm zum Steuern eines Zustandsanalysegeräts (30) gespeichert hat, das einen Mikroprozessor (50) hat, einen Read/Write-Speicher und den nichtflüchtigen Speicher (40), wobei das Computerprogramm umfasst:
eine Programmfunktion, die beim Lauf auf dem Mikroprozessor bewirkt, dass das Analysegerät einen Zustandswert abhängig von dem gegenwärtigen Zustand einer Maschine erzeugt, indem eine Messung an einem Messpunkt der Maschine durchgeführt wird;
gekennzeichnet durch
eine Programmfunktion, die beim Lauf auf dem Mikroprozessor bewirkt, dass das Analysesystem den Zustandswert als ein Bezugszustandswert in einem beschreibbaren Informationsträger (120) speichert, der auf, an oder in der Nähe des Messpunkts (90) platziert ist.

34. Nichtflüchtiger Speicher nach Anspruch 33, wobei das Computerprogramm weiter umfasst:

eine Programmfunktion, die beim Lauf auf den Mikroprozessor bewirkt, dass das Analysegerät einen Messwert erzeugt, der von einer Bewegung der Maschine abhängt;

eine Programmfunktion, die beim Lauf auf den Mikroprozessor bewirkt, dass das Analysegerät Auswertungsinformation von dem Informationsträger enthält, der auf, an, oder in der Nähe des Messpunkts montiert ist;

eine Programmfunktion, die beim Lauf auf dem Mikroprozessor bewirkt, dass das Analysegerät einen gegenwärtigen Zustandswert erzeugt, der den gegenwärtigen Zustand des Messpunkts auf der Maschine angibt, abhängig von dem Messwert und der Auswertungsinformation;

eine Programmfunktion, die beim Lauf auf dem Mikroprozessor bewirkt, dass das Analysegerät den Bezugszustandswert von dem Informationsträger erhält, der den Zustand des Messpunkts zu einem früheren Zeitpunkt angibt;

eine Programmfunktion, die beim Lauf auf dem Mikroprozessor bewirkt, dass das Analysegerät einen Verhältniswert abhängig von dem gegenwärtigen Zustandswert und dem Bezugszustandswert erzeugt, wobei der Verhältniswert eine Änderung des Zustands der Maschine angibt.

Revendications

1. Procédé pour l'évaluation de l'état d'une machine (100) comportant un point de mesure (90), dans lequel une valeur d'état est obtenue en réalisant une mesure au niveau du point de mesure, ladite valeur d'état étant fonction de l'état actuel de la machine;
   caractérisé par le fait de stocker la valeur d'état dans un support d'information inscriptible (120) placé sur, ou dans le voisinage, du point de mesure (90) de façon que la valeur d'état puisse ensuite être utilisée comme valeur d'état de référence, grâce à quoi des changements d'état ultérieurs possibles peuvent être déterminés par comparaison avec ladite valeur d'état de référence.

2. Procédé selon la revendication 1, **caractérisé par** le fait de :

   - produire une valeur mesurée;
   - recueillir des informations d'interprétation (d_1, V_1);
   - générer la valeur d'état en fonction de la valeur mesurée (A_v) et des informations d'interprétation recueillies (d_1, V_1).

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** la valeur mesurée indique un mouvement, tel qu'une vibration, de la machine.

4. Procédé selon la revendication 1, 2 ou 3, **caractérisé en ce que** la valeur mesurée indique une température de la machine au niveau du point de mesure.

5. Procédé selon la revendication 2, **caractérisé en ce que** les informations d'interprétation (d_1, V_1) correspondent aux valeurs techniques types pour la machine ou une partie de la machine.

6. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la mesure comporte l'étape consistant à attacher un capteur (20) au point de mesure.

7. Procédé selon la revendication 1, comprenant en outre les étapes consistant à :

   - produire une seconde valeur d'état actuel à un instant ultérieur au temps de production de ladite valeur d'état de référence, ladite seconde valeur d'état actuel étant fonction de l'état actuel au niveau du point de mesure,
   - recueillir ladite valeur d'état de référence à partir du support d'information (120) qui est placé sur, ou dans le voisinage, du point de mesure (90).

8. Procédé selon la revendication 7, comprenant en outre l'étape consistant à :
   produire une valeur de relation en fonction de la seconde valeur d'état actuel et de la valeur d'état de référence.

9. Procédé selon la revendication 7 ou 8, **caractérisé en ce que** la production de la seconde valeur d'état actuel comprend les étapes consistant à :

   - produire une valeur mesurée en réalisant une mesure au niveau du point de mesure;
   - recueillir des informations d'interprétation provenant du support d'information (120); et
   - générer la seconde valeur d'état actuel (K) en fonction de la valeur mesurée (A_v) et des informations d'interprétation (d_1, V_1).

10. Procédé selon la revendication 7 ou 8, **caractérisé en ce que** la seconde valeur d'état actuel est produite directement en réalisant une mesure au niveau du point de mesure.

11. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** le fait de communiquer avec le support d'information par communication radio ou optique.

12. Appareil d'analyse pour l'évaluation de l'état d'une machine (100) comportant un point de mesure (90), lequel appareil comprend :

   - un capteur (20) servant à produire une valeur mesurée (A_v) en fonction d'un mouvement de la machine;
   - un moyen de communication (70; 66; 64) pour recevoir des informations d'interprétation;
   - un moyen (50, 40, 60) de traitement d'informations pour produire une valeur d'état, **caractérisé en ce que**

   le moyen (50, 40, 60) de traitement d'informations coopère avec le moyen de communication (70; 66; 64) et le capteur (20) de façon que le moyen de traitement d'informations produise une valeur d'état (K; K_{ref}) dépendant de la valeur mesurée et des informations d'interprétation, indiquant l'état actuel de la machine,
   le moyen de communication comprend un moyen formant interface (70) qui est conçu pour transmettre la valeur d'état (K_{ref}) à un support d'information inscriptible (120) placé sur, ou dans le voisinage, du point de mesure (90) de façon qu'elle puisse être utilisée comme valeur de référence d'état individuelle stockée localement, spécifique au point de mesure, grâce à quoi des changements d'état ultérieurs possibles peuvent être déterminés par comparai-

son avec ladite valeur d'état de référence.

13. Appareil d'analyse selon la revendication 12, **caractérisé en ce que** :

le moyen formant interface (70) peut aussi bien recevoir qu'émettre des informations.

14. Appareil d'analyse selon la revendication 12, **caractérisé en ce que** :

le capteur (20) est relié de manière mobile au moyen de traitement d'informations.

15. Appareil d'analyse selon la revendication 12, 13 ou 14,
caractérisé en ce que :

le moyen formant interface (70) et le capteur (20, 140) sont intégrés dans un boîtier commun.

16. Appareil d'analyse selon l'une quelconque des revendications 12 à 15, **caractérisé en ce que** l'appareil d'analyse est conçu pour générer la valeur d'état selon un algorithme prédéterminé.

17. Appareil d'analyse selon l'une quelconque des revendications 12 à 16, **caractérisé en ce que** l'appareil d'analyse est une unité portable.

18. Appareil d'analyse selon l'une quelconque des revendications 12 à 17, **caractérisé en ce que** :

le moyen formant interface (70) est adapté pour communiquer avec le support d'information au moyen d'une communication radio ou au moyen d'émetteurs optiques et de récepteurs optiques.

19. Système pour l'évaluation de l'état d'une machine, comprenant :

- un appareil d'analyse mobile (30) et un capteur (20) pour produire une valeur d'état en réalisant une mesure au niveau d'un point de mesure situé sur la machine, ladite valeur d'état étant fonction du mouvement et représentant l'état actuel de la machine; et
- un dispositif (80) comprenant un support d'information (120) placé sur, au niveau de, ou dans le voisinage, du point de mesure (90) de la machine;

caractérisé en ce que

l'appareil d'analyse (30) est conçu pour stocker la valeur d'état dans le support d'information (120), qui est inscriptible, de sorte que la valeur d'état peut ensuite être utilisée comme valeur d'état de référence.

20. Système selon la revendication 19, dans lequel le dispositif (80) comprend des informations d'interprétation, stockées sur le support d'information, qui définissent des valeurs techniques types pour la machine et/ou la partie mobile de telle manière que la valeur d'état actuel peut être générée en fonction d'une valeur mesurée actuelle et des informations d'interprétation.

21. Système selon la revendication 20, dans lequel

le dispositif (80) comprend un moyen de communication (130) destiné à coopérer avec le support d'information (120) et à communiquer avec l'appareil d'analyse (30).

22. Système selon la revendication 21, **caractérisé en ce que** le moyen de communication (130) comprend un émetteur-récepteur pour communiquer avec l'appareil d'analyse (30) au moyen d'une communication radio ou au moyen d'émetteurs optiques et de récepteurs optiques.

23. Système selon la revendication 21, **caractérisé en ce que**

le moyen de communication (130) comprend un moyen de contact pour permettre un contact ohmique entre le support d'information (130) et l'appareil d'analyse (30, 70).

24. Système selon l'une quelconque des revendications 19 à 23, **caractérisé en ce que** la valeur d'état produite par ledit capteur dépend des vibrations.

25. Système selon l'une quelconque des revendications 19 à 23, **caractérisé en ce que** le dispositif (80) est monté de manière rigide sur la machine (100), sur, au niveau de, ou au voisinage, du point de mesure (90).

26. Système selon l'une quelconque des revendications 19 à 25, **caractérisé en ce que** .

le point de mesure comprend un raccord de connexion qui est fermement attaché à l'enveloppe de la machine (100); le capteur pouvant être attaché de manière amovible au raccord de connexion.

27. Système selon la revendication 26, **caractérisé en ce que**

le raccord de connexion est un raccord à baïonnette.

28. Système selon l'une quelconque des revendications 19 à 26, **caractérisé en ce que**

le point de mesure comprend une cavité filetée dans l'enveloppe de la machine (100) dans laquelle le capteur peut être vissé.

29. Système selon la revendication 28, **caractérisé en ce que**

le capteur (20) comprend un filetage correspondant de sorte qu'il peut être introduit dans la ca-

vité comme une vis.

30. Système selon l'une quelconque des revendications 19 à 29, **caractérisé en ce que**

l'appareil d'analyse (30) comprend une mémoire non volatile (40), une mémoire vive (60), un microprocesseur (50) et un module d'affichage (62) pour afficher l'état d'un point de mesure courant.

31. Système selon la revendication 30, **caractérisé en ce que**

le microprocesseur (50) est connecté à un port d'information (66), grâce auquel l'appareil d'analyse (30) peut être relié à un module de traitement d'informations séparé.

32. Système selon la revendication 20, dans lequel le dispositif (80) comprend un moyen de communication (130) destiné à coopérer avec l'appareil d'analyse, qui, en fonction d'un signal d'activation, lit une information d'interprétation dans le support d'information et délivre cette information à l'appareil d'analyse; et dans lequel le moyen de communication, en fonction du signal d'activation, lit la valeur d'état de référence dans le support d'information et la délivre à l'appareil d'analyse, permettant ainsi la génération d'une valeur de relation indiquant un état changé.

33. Mémoire non volatile (40) dans laquelle est stocké un programme informatique pour commander un appareil d'analyse (30) d'état comportant un microprocesseur (50), une mémoire vive et ladite mémoire non volatile (40), le programme informatique comprenant :

une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige l'appareil d'analyse à produire une valeur d'état qui est fonction de l'état actuel d'une machine, en réalisant une mesure au niveau d'un point de mesure de la machine;

caractérisée par

une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige le système d'analyse à stocker la valeur d'état en tant que valeur dé référence dans un support d'information inscriptible (120) placé sur, à proximité, ou au voisinage du point de mesure (90).

34. Mémoire non volatile selon la revendication 33, dans laquelle le programme informatique comprend en outre :

- une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige l'appareil d'analyse à produire une valeur mesurée qui dépend d'un mouvement de la machine;
- une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige l'appareil d'analyse à recueillir des informations d'interprétation provenant du support d'information qui est monté sur, à proximité, ou au voisinage du point de mesure;
- une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige l'appareil d'analyse à produire une valeur d'état actuel, indiquant l'état actuel du point de mesure de la machine, en fonction de la valeur mesurée et des informations d'interprétation;
- une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige l'appareil d'analyse à recueillir ladite valeur d'état de référence, indiquant l'état du point de mesure à un instant antérieur, et provenant du support d'information;
- une fonction de programme qui, lorsqu'elle est exécutée dans le microprocesseur, oblige l'appareil d'analyse à produire une valeur de relation qui est fonction de la valeur d'état actuel et de la valeur d'état de référence, laquelle valeur de relation indique un changement dans l'état de la machine.

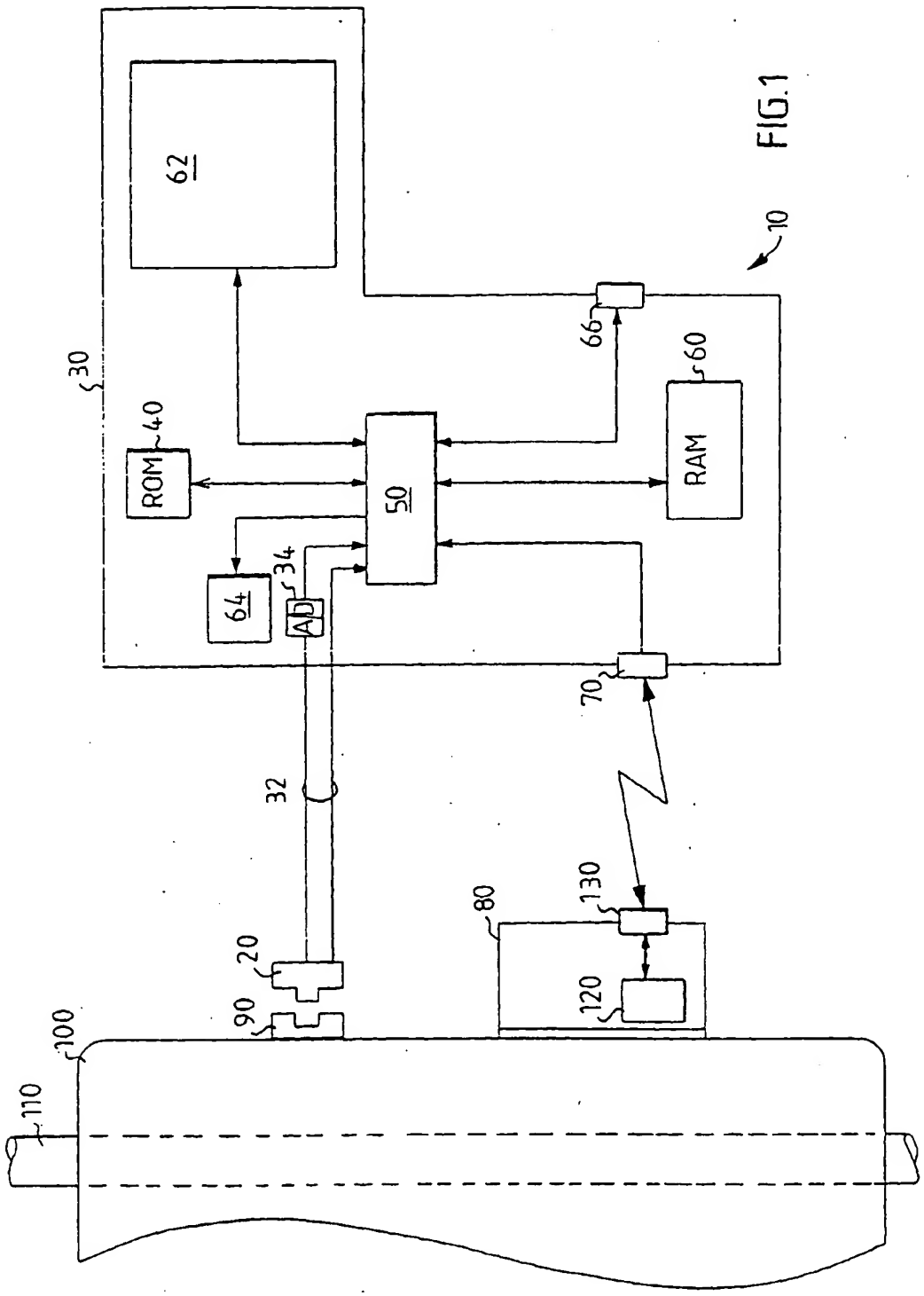

FIG.1

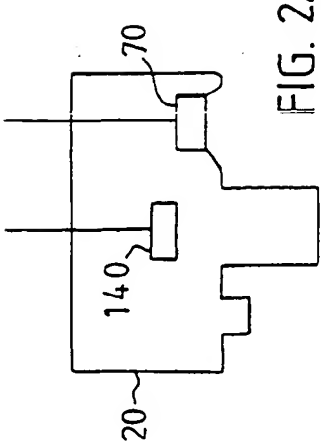

FIG. 2A

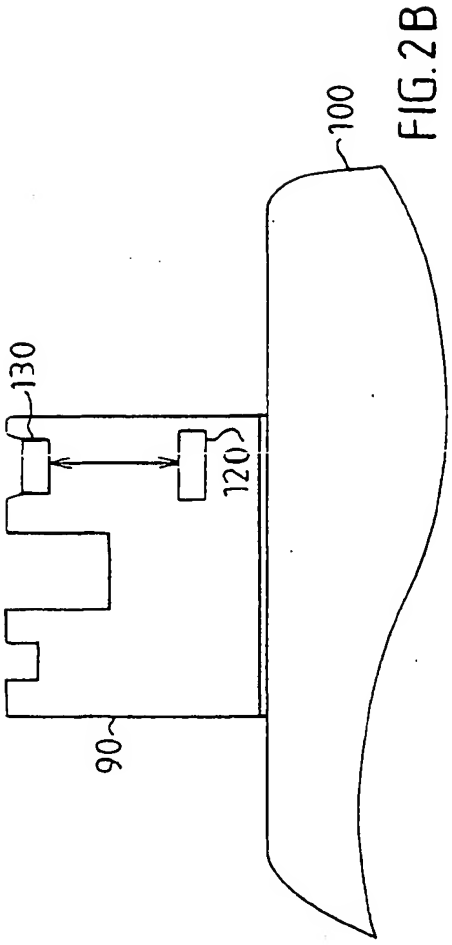

FIG. 2B